

RUPTURE OF THE COLON BY COMPRESSED AIR

REPORT OF THREE CASES

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COMPRESSED AIR came into rather general use in industry at about the beginning of the twentieth century. In 1904, Stone¹ reported a fatal case of rupture of the bowel caused by compressed air introduced per rectum from a machine which was pumped by hand. In 1908, Petren² wrote about a case of fatal rupture of the esophagus from accidental oral insufflation. In 1911, Andrews³ reported a case of pneumatic rupture of the sigmoid colon which recovered following resection of the injured loop. He also discussed the subject quite completely and recorded 15 other cases collected by correspondence and from law reports. Later in the same year, Lenormant⁴ reviewed the previous papers and discussed the subject editorially in the *Presse Medicale*, of Paris. The following year, Cotton⁵ reported the recovery of a case of perforation of the ascending colon—he established a temporary colostomy at the site of the perforation and repaired several rents in the serous and muscular coats of other portions of the colon. In 1914, Bendixen and Blything⁶ reported another recovery—a case of pneumatic rupture of the transverse colon, and gave brief notes on seven collected cases which were fatal. Buchbinder⁷ reported a fatal case in 1921.

There have been a number of more recent publications on this subject. Table I gives a brief summary of cases of complete rupture of the bowel from compressed air that we have found in a rather thorough search of the literature.* Hays¹³ was apparently the first American author who was aware of Stone's original contribution. Burt¹⁶ found that under experimental conditions the human colon bursts with only about 4 lbs. pressure, and that the serous and muscular coats tear first at about 3½ lbs. pressure. Table II summarizes cases of incomplete rupture of the bowel. These two tables, and our bibliography, are arranged according to dates of publication. Our three cases illustrate various degrees of severity of bowel injury from compressed air.

CASE REPORTS

Case 1.—Dr. James H. Lewis: Complete Rupture of Transverse Colon with Marked Abdominal Distention. H. Z., white, male, age 21, was admitted to the Moses Taylor

* Data on two cases of Fauquez (Burt¹⁶); one of Houzel (Burt¹⁶), and one of Semerikov²⁰ are not included.

TABLE I
PNEUMATIC BOWEL PERFORATION

No.	Author	Year	Age	Pounds Press- ure	Opera- tion	Treatment		Site of Perforation	Result
						Time After Injury			
1	Stone.....	1904	17	20	Yes	(trochar)		Sigmoid	Died
2	Andrews.....	1910		60	Yes	5 hrs.		Sigmoid	Recovered
3	(1) Fletcher.....	1907	36	70	Yes	4½ hrs.		Sigmoid	Recovered
4	(2) Tilney.....	1907	21	—	No			—	Died, third day
5	(3) Currie.....	1906	—	40— 100	Yes	?		—	Died
6	(4) (Ballard).....	1908	—	—	No			—	Died
7	(5) Boughton.....	1910	39	—	Yes			Sigmoid (3 places)	Recovered
8	(6) Stevens.....	1910	20	—	Yes	9 hrs.		Splenic flexure	Died
9	(7) Sherman.....	—	—	—	No			—	Died (autopsy)
10	(8) (Banquet).....	—	25	—	No			Rectum (2 places)	Died (autopsy)
11	(9) (Kaseberg).....	1908	22	—	No			Rectum	Died (autopsy)
12	(10) (Borgan).....	1906	25	—	No			Rectum	Died (autopsy)
13	(11) (Jaworski).....	1905	47	—	Yes			Sigmoid	Died (autopsy)
14	(13) Burry.....	1907	20	125	Yes			Colon (3 places)	Died (autopsy)
15	(15) Godfrey.....	1908	19	80	No			Upper end sigmoid	Died (autopsy)
16	Cotton.....	1912	—	—	Yes	3 hrs.		Ascending colon	Recovered
17	Bendixen & Blything	1912	20	100— 125	Yes	2 hrs.		Transverse colon	Recovered
18	(1) (Orth).....	1908	—	—	Yes			—	Died, 3 hrs.
19	(3) (Dagenais).....	1906	15	—	Yes	4 days		Sigmoid	Died (autopsy)
20	(5) (Denney).....	—	—	—	No			—	Died
21	(6) Groman.....	—	15	—	Yes	After trochar		Near cecum	Died
22	(7) Mecray.....	1913	17	10	No			Colon (8 places)	Died (autopsy)
23	Buchbinder.....	1920	—	85	Yes			Sigmoid (gangrene)	Died (autopsy)
24	Jean (1).....	—	—	—	Yes	4 hrs.		Rectosigmoid junction	Recovered
25	(2).....	—	—	—	Yes	2½ hrs.		Sigmoid	Recovered
26	Hailes.....	—	—	—	Yes	19 hrs.		Colon	Died
27	Sparkman.....	1922	—	—	Yes	3 hrs.		Sigmoid	Recovered
28	Block & Weissman ..	1925	45	125	(centesis) Yes	5½ hrs.		Sigmoid	Recovered
29	Hays.....	1923	30	95	Yes	1 hr. 50 min.		Rectum	Recovered
30	Patterson.....	1930	—	—	Yes			Hepatic flexure	Recovered
31	Burt (1).....	—	49	2	Yes			Iliac (old colitis)	Died
32	(a) Shoudy.....	1927	—	—	Yes			Many	Recovered
33	(b) Shoudy.....	1916	—	—	No			—	Died
34	(c) Shoudy.....	1927	—	—	Yes			—	Recovered
35	(2) Moorehead.....	1928	37	—	Yes	25 hrs.		Sigmoid (3 places)	Recovered
36	Ide.....	1930	—	—	Yes	3 hrs.		Sigmoid	?
37	(1) L. F.	—	12	—	Yes			Rectum, sigmoid and descending colon	Died
38	(2)	—	—	—	Yes			Lower end of sigmoid	Died
39	(3)	—	—	—	No			—	Died
40	(4) C. R.	1920	—	—	No			—	Died
41	(5)	1918	16	—	?			—	Died
42	(6) Nilsson.....	1926	—	—	No			—	Died
43	(7)	1914	21	—	Yes			—	Died
44	(8)	—	—	—	No			—	Died
45	(10) Wainwright... ..	—	—	90	Yes	6 hrs.		Loud explosion	Recovered
46	(11)	—	—	—	Yes			Sigmoid	Recovered
47	(12)	—	—	—	Yes			—	Died, 5 hrs.
48	(13)	—	—	—	(centesis) No			—	Died, 24 hrs.
49	(14)	—	—	—	No			—	Died
50	(15)	1936	—	—	No			—	Died
51	(16) Mr. P.	—	—	—	No			—	Died
52	(17) A. L.	—	—	—	?			Colon	Died

PNEUMATIC RUPTURE OF BOWEL

TABLE I (Continued)

No.	Author	Year	Age	Treatment		Site of Perforation	Result
				Pounds Press-ure	Opera-tion		
53	(18)	1915	—	—	No	Rectum	Died, 3 hrs.
54	(19) J. H.	1915	—	—	?	—	Died
55	(20)	1920	—	—	?	Colon	Died, 8 days
56	(21)	1936	—	90	Yes	—	Died during operation
57	(23) Cereal	—	—	—	?	—	Died
58	(24)	—	—	—	?	Sigmoid	Died
59	(25)	—	—	—	?	—	Died
60	Ritchie	—	—	—	Yes	6 hrs. Sigmoid	Recovered

TABLE II

PNEUMATIC BOWEL INJURY WITHOUT PERFORATION

No.	Author and Case Mark	Date	Age	Lbs. Air Press-ure	Treat-ment	Pathology	Result
1	Andrews XII Kahlke	1906	20	—	Operation; 18 hrs.	Colon ruptured entire length, except for 1 or 2 narrow bands. Mucosa was not perforated.	Died
2	XIV Burry	1908	—	—	None	Insufflation with live steam.	Recovered
3	Bendixen & Blything (Orth)	1913	16	85	None	Returned to work shortly.	Recovered
4	(Kay)	1905	—	—	None	Recovery rapid and complete.	Recovered
5	Schwartz	1922	—	20-70	Operation; 6 hrs.	No perforation found but serous and muscular coats of large intestine were lacerated.	Recovered
6	Morris	1923	—	60-65	Operation	Mucosa bulged through 7-inch tears on each side of cecum. Sigmoid had a number of small tears, but mucosa not ruptured.	Recovered
7	Ide IX	1929	—	—	None	Not serious; returned to work in 10 days.	Recovered
8	XXII	—	—	—	None	Injuries minor. No disability.	Recovered
9	Neesse	1936	42	75	Operation	Multiple areas of herniation of mucosa of descending colon and sigmoid—due to tearing of serous and muscular coats. No perforations.	Recovered

Hospital, April 1, 1915. He had collapsed immediately after air was released from a nozzle which was held against the seat of his trousers. At the time of admission he was in profound shock. Temperature, by mouth, 96° F., pulse 92, respirations 26. The abdomen was markedly distended; liver dulness to percussion was absent. The lower extremities were blue and cold. There was a protrusion at the anus, and prostatic secretion was noticed at the urinary meatus. A rectal tube was inserted but no air escaped. Vomitus was fecal.

Operation.—About two hours after the injury: Under general ether anesthesia, a midline incision above and below the umbilicus was made. The skin and underlying tissues retracted widely. When the peritoneum was opened there was a sudden deflation. The pelvis contained a brownish-red fluid. There were several tears through the serous and muscular coats of the transverse colon and in its midportion there was an opening through the mucous layer about one inch long. Both the ascending and descending colon had been loosened from the parietes in places; at the iliocaecal junction there was an ecchymosis three inches in diameter. The small intestines contained air and the gall-bladder was distended with air, being three and one-half inches long and one and one-half

inches in diameter. The perforation was sutured; the peritoneal cavity was sponged grossly clean; drains were inserted; and the wound was closed.

The postoperative course was stormy. A fecal fistula developed, which closed spontaneously. The patient left the hospital in good health 90 days after the accident.

Case 2.—Dr. James H. Lewis: Incomplete Ruptures of Rectum and Sigmoid Colon. J. B., white, male, age 40, was admitted to the Moses Taylor Hospital, August 6, 1916, complaining of abdominal pain and vomiting, which occurred immediately after his fellow workmen released the compressed air against his anus. Temperature 96.8° F., pulse 74, respirations 20. He seemed to be in great pain and was dazed. There was slight rigidity in both lower quadrants of the abdomen; but there was no bulging or distention.

Operation.—Six hours after injury: Under general ether anesthesia, an incision was made in the midline below the umbilicus. There was no noticeable escape of air when the peritoneum was opened. There were five tears in the serous and muscular coats of the sigmoid colon, and one of the rectum; but no perforation in the mucosa was discovered. These tears were sutured and the abdomen was closed. A rectal tube was inserted. The patient made an uneventful recovery and was discharged from the hospital 30 days after the injury.

Case 3.—Drs. Brown and Dwinelle: Complete Rupture of Sigmoid Colon, without Abdominal Distention. W. R., white, male, age 24, was admitted to the Moses Taylor Hospital, July 29, 1939. The patient had a tear along the seam of his trousers on the medial aspect of his thigh, into which a fellow workman, jokingly, had directed the compressed air jet. He felt some pain in the upper part of the abdomen and had to sit down because of weakness. In a few minutes he felt better, changed his clothes and walked to the dispensary. Temperature 99° F., pulse 88, respirations 20, blood pressure 120/84. At this time he had practically no pain. There was no distention of the abdomen; there was no rigidity, and only slight tenderness just above the symphysis pubis. There was no area of dullness to percussion in the region of the liver. A roentgenogram of the abdomen in the erect position showed air between the diaphragm and the liver (Fig. 1).

Operation.—Four hours after the injury: Under general ether anesthesia, a low left rectus incision was made. The peritoneum was opened beneath sterile saline solution; air bubbled out as soon as the peritoneum was incised. There was a little blood mixed with fecal material in the pelvis. An irregular stellate rupture about two inches long in the lower part of the sigmoid flexure was sutured with silk with considerable difficulty. A rectal tube was guided up past the site of injury; cigarette drains were placed on either side of the injured bowel; and the abdomen was closed in layers. A fecal fistula developed which closed spontaneously 24 days after the accident. The patient left the hospital in good health on the 58th day.

Pathogenesis.—This accident is not uncommon, because the public is not aware of the fact that a compressed air jet is a lethal weapon. All the victims were males, between the ages of 12 and 49. Many cases are due to pranks, but not all of them. Workmen should never dust off their clothes with compressed air.

The jets that are used in industry are usually said to have a pressure of from 50 to 100 lbs. or more. The nozzles are pipes one-quarter to one inch in diameter; sometimes the rubber hose is used without a nozzle. Usually one thinks of these jets in terms of experience with visible streams of water from a nozzle; but the gaseous jet differs in that it is elastic and expands in all directions, adapting itself to surroundings, bending and twisting and causing eddy currents.

Such an air jet enters the anus more readily than the examining finger or a proctoscope, as it passes through clothing and enters the bowel even when not accurately directed at the anus, as in Case 3. It has been suggested³ that the thighs, buttocks and perineum form a funnel which delivers the stream of air to the anus. Gases under pressure pass through small apertures very rapidly. Compressed air has been known to enter a hangnail accidentally and produce signs suggestive of gas gangrene of the hand and forearm.

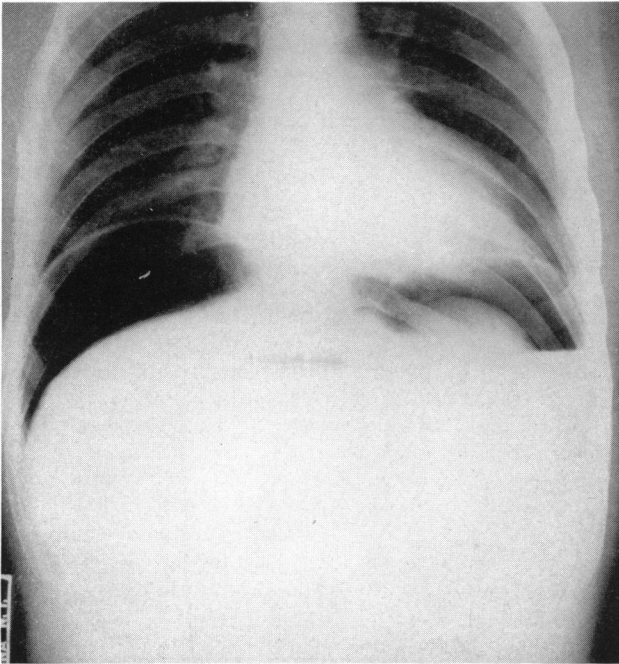


FIG. 1.—Case 3: Preoperative roentgenogram; sitting up. Shows gas beneath the diaphragm.

Rupture of the intestine perhaps depends more upon the suddenness of the pressure than upon its amount, for the bowel will expand enormously if given time to relax. Duval (quoted by Burt¹⁶) observed great dilatation of the colon in a deranged patient who inflated himself by means of a hand bicycle pump. Operation was performed in error, with a diagnosis of megacolon, and no abnormality was found.

Apparently the muscularis mucosae adapts itself more readily to sudden changes in tension than the outer muscular coats of the bowel. Rents in the muscle, usually along one of the longitudinal bands, with the underlying mucosa intact, have been observed in many cases. Case 2, and at least some of those listed in Table II, illustrate the occurrence of these incomplete lacera-tions without any associated complete perforation. The inner mucosal tube balloons out through the split outer muscular tube, like the "blow-out" of a pneumatic tire. The bursting defect in the inner tube is usually smaller than

the rent in the outer tube; it may retract beneath the edge of the outer tear. When there are multiple lacerations, complete rupture through all the layers is usually found in only a few, perhaps in only one of them. The most common lesion is a complete perforation at the angulation where the sigmoid colon joins the rectum, as in Case 3.

Figure 2 shows the approximate distribution of perforations in 32 cases. Autopsy records of some of the cases in Table I indicate that the injury destroyed the blood supply of segments of the colon (Buchbinder⁷); but this seems to be rare. Tearing of the ascending and descending colon from parietal attachments, as in Case 1, has been observed in a number of cases. The entire intestinal canal may be filled with air. It is difficult to understand how the air got into the gallbladder in Case 1. Subcutaneous emphysema of the trunk occurs when the distention is great.

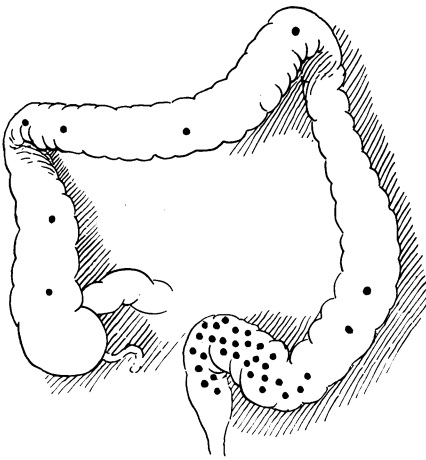


FIG. 2.—Schematic drawing showing the approximate location of 38 perforations in 32 cases. Two cases each, had three perforations in the sigmoid colon. One case had two perforations in the sigmoid colon. Twenty-nine cases had single perforations.

Mecray's case (Bendixen and Blything⁶), in which "the colon was ruptured in eight places," and others not definitely described as to location, are not included in the drawing.

Diagnosis.—The history in these cases has often been obscured by language difficulties, and by attempts to conceal the facts. There should be no difficulty in diagnosis from the history alone, when properly elicited. Abdominal pain is immediate, perhaps most severe in the upper part of the abdomen, radiating to the shoulders. The patient is usually prostrated. In the more severe cases, there is enormous ballooning of the abdomen, with cyanosis resulting from embarrassment of respiration and circulation. Subcutaneous emphysema of the trunk may be present. The uniformity of the tympany over the entire abdomen has been considered diagnostic.

When the distention is not great, the pain in the upper part of the abdomen may disappear, leaving the patient quite comfortable until local pain in the region of the perforation develops, as in Case 3. In this case, obliteration of the liver dulness was the only positive physical sign. Roentgenograms taken with the patient erect show the gas between the liver and diaphragm (Fig. 1).

Treatment.—When distention is great, immediate paracentesis should be performed. The general condition may improve remarkably after simple relief of intra-abdominal pressure; even moribund patients may rally sufficiently to warrant celiotomy. To illustrate the tension that may be present we will quote Wainwright (Ide¹⁷): "When the peritoneum was opened there was a loud escape of gas under high pressure, almost as loud as the report of a small automobile tire." Buchbinder's⁷ description is also of interest in

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this detail: "The transversalis fascia was not incised but sharp-nosed forceps were pushed through in order to control the escape of air. The fascia immediately tore like wet paper under great tension; the air rushed out with a report, and the abdominal wall dropped in. The sudden escape of air nearly proved fatal, but after a few moments the patient rallied, and his general condition seemed much improved."

Rectal tubes are of no avail. Enemata are of course very harmful. Ritchie's¹⁸ case was given a soapsuds enema and then a turpentine enema at home before a doctor was called. The fluid was removed from the peritoneal cavity; the rent in the sigmoid was repaired—and the man recovered.

Operation should be performed as soon as possible. The incision should be large enough for exposure of all of the colon. The defects in the bowel should be closed as quickly as possible. Resection is of course necessary when the blood supply of the bowel has been destroyed by the injury. Usually, simple suture of the rent is sufficient, but it may be difficult because of the irregular shape of the bursting laceration, and because the tear in the mucosal layer does not correspond accurately to that of the muscular layers. Drainage is usually advisable, not only because of the contamination, but also because of doubt as to the adequacy of the closure of the bowel. Colostomy and enterostomy have been performed. If the perforation is at or near the sigmoid flexure, it is better to have a long soft rectal tube inserted while the abdomen is still open, and guide it past the site of injury. The postoperative care is that of any other potential peritonitis case.

Prognosis.—Many of the cases listed in the literature are of little value for statistics because insufficient information is given. Table III summarizes the results of treatment. Recovery is usual when only the serous and muscular coats are torn. However, most of the cases had one or more complete perforations; in this larger group the prognosis is grave unless an adequate operation is performed within a few hours.

TABLE III
RUPTURE OF COLON FROM COMPRESSED AIR

	Result Unknown	Recov- ered	Died	Mortality Percentage
<i>Incomplete Rupture:</i>				
(Operative cases only)				
Our case #2 and 4 cases from the literature.....		4	1	20%
<i>Complete Perforation:</i>				
Our cases #1 and #3 and 60 cases from the literature.....	1	19	42	69%
Treatment unknown.....			7	
Without operation.....		0	21	100%
With operation.....	1	19	14	42%

CONCLUSIONS

Pneumatic rupture of the colon is produced by a jet of compressed air, which readily passes through clothing and enters the anus. Perforation

occurs at the rectosigmoid angle or, less frequently, at some other flexure of the colon. Rarely, only the serous and muscular coats of the bowel are torn.

The diagnosis may be made on the basis of the history alone, or by the physical signs alone. Absence of liver dulness may be the only important early physical finding. Roentgenologic examination in the erect position, in order to demonstrate air between liver and diaphragm, is a valuable aid in doubtful cases.

When distention is great and respiration is embarrassed, paracentesis should be performed immediately. Early celiotomy with appropriate repair offers good hope of recovery.

BIBLIOGRAPHY

- ¹ Stone, G. W.: Rupture of the Bowel Caused by Compressed Air. *Lancet*, **2**, 216, 1904.
- ² Petren, G.: Ein Fall von traumatischer Oesophagusruptur, nebst Bemerkungen über die Entstehung der Oesophagusrupturen. *Beitr. z. klin. Chir.*, **61**, 265, 1908.
- ³ Andrews, E. W.: Pneumatic Rupture of the Intestine—a New Type of Industrial Accident. *Surg., Gynec., and Obstet.*, **12**, 63, 1911.
- ⁴ Lenormant, C.: Une variété d'accident du travail; les ruptures du tube digestif produites par l'air comprimé. *Presse méd.*, Paris, **19**, 486, 1911.
- ⁵ Cotton, F. J.: Rupture of the Bowel from Compressed Air. *Boston Med. Surg. Jour.*, **166**, 562, 1912.
- ⁶ Bendixen, P. A., and Blything, J. D.: Pneumatic Rupture of the Bowel. *Surg., Gynec., and Obstet.*, **18**, 73, 1914.
- ⁷ Buchbinder, J. R.: Pneumatic Rupture of the Intestine. *J.A.M.A.*, **76**, 518, 1921.
- ⁸ Jean, G.: Ruptures recto-colique produites par l'air comprimé. *Presse méd.*, Paris, **29**, 625, 1921; and *Bull. et mém. Soc. de chir. de Par.*, **47**, 440, 1921.
- ⁹ Hailes, W. A.: Rupture of the Bowel by Compressed Air. *Med. Jour. Australia*, **2**, 538, 1921.
- ¹⁰ Sparkman, J. R.: Unusual Case of Intestinal Rupture. *Jour. S. Carolina Med. Assn.*, **18**, 324, 1922.
- ¹¹ Schwartz, H.: Pneumatic Rupture of the Intestines. *J.A.M.A.*, **78**, 1802, 1922.
- ¹² Block, F. B., and Waissman, M. I.: Pneumatic Rupture of the Sigmoid. *J.A.M.A.*, **86**, 1597, 1926.
- ¹³ Hays, G. L.: Pneumatic Rupture of the Bowel. *Surg., Gynec., and Obstet.*, **43**, 491, 1926.
- ¹⁴ Morris, R. B.: Pneumatic Rupture of Intestine with Roentgen Ray Studies Following Recovery; Case Report. *Am. Jour. Roentgenol.*, **18**, 560, 1927.
- ¹⁵ Patterson, D. C.: Compressed Air Rupture of Intestines. *New England Jour. Med.*, **202**, 118, 1930.
- ¹⁶ Burt, C. A. V.: Pneumatic Rupture of the Intestinal Canal; with Experimental Data Showing the Mechanism of Perforation and the Pressure Required. *Arch. Surg.*, **22**, 875, 1931.
- ¹⁷ Ide, A. W.: Pneumatic Rupture of the Bowel. *Journal-Lancet*, **56**, 230, 1936.
- ¹⁸ Ritchie, H. P.: (discussion of Ide's¹⁷ paper). *Journal-Lancet*, **56**, 233, 1936.
- ¹⁹ Neese, C. C.: Rupture of the Intestinal Canal with Compressed Air. *Tr. Am. Proct. Soc.*, **81**, 153, 1937.
- ²⁰ Semerikov, A. P.: Rupture of Colon Due to Compressed Air; Case Report. *Khirurgiya*, **12**, 153, 1937.

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